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Interested committees:

Title: Draft BS EN 60079-7 Explosive atmospheres. Part 7: Equipment protection by increased safety.

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- i) has any issues related to 3rd party IPR, patent or copyright
- ii) affects other national standard(s)
- iii) requires additional national guidance or information

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

- **Annotated drafts are not acceptable and will be rejected.**
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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



31/1602/CD

COMMITTEE DRAFT (CD)

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31/1519/CD, 31/1535A/CC

IEC TC 31 : EQUIPMENT FOR EXPLOSIVE ATMOSPHERES

SECRETARIAT:

United Kingdom

SECRETARY:

Mr Mick Maghar

OF INTEREST TO THE FOLLOWING COMMITTEES:

PROPOSED HORIZONTAL STANDARD:

☐

Other TC/SCs are requested to indicate their interest, if any, in this CD to the secretary.

FUNCTIONS CONCERNED:

☐ EMC

☐ ENVIRONMENT

☐ QUALITY ASSURANCE

☐ SAFETY

This document is still under study and subject to change. It should not be used for reference purposes.

Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

TITLE:

Explosive atmospheres - Part 7: Equipment protection by increased safety "e"

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

EXPLOSIVE ATMOSPHERES –**Part 7: Equipment protection
by increased safety "e"****FOREWORD**

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International Standard IEC 60079-7 has been prepared by IEC Technical Committee 31: Equipment for explosive atmospheres.

This sixth edition cancels and replaces the fifth edition published in 2015, and constitutes a technical revision.

Table of Changes to be added at CDV stage.

NOTE The technical changes referred to include the significance of technical changes in the revised IEC Standard, but they do not form an exhaustive list of all modifications from the previous version.

Explanations:**A) Definitions**

Minor and editorial changes clarification
decrease of technical requirements
minor technical change
editorial corrections

These are changes which modify requirements in an editorial or a minor technical way. They include changes of the wording to clarify technical requirements without any technical change, or a reduction in level of existing requirement.

Extension addition of technical options

These are changes which add new or modify existing technical requirements, in a way that new options are given, but without increasing requirements for equipment that was fully compliant with the previous standard. Therefore, these will not have to be considered for products in conformity with the preceding edition.

Major technical changes addition of technical requirements
increase of technical requirements

These are changes to technical requirements (addition, increase of the level or removal) made in a way that a product in conformity with the preceding edition will not always be able to fulfil the requirements given in the later edition. These changes have to be considered for products in conformity with the preceding edition. For these changes additional information is provided in clause B) below.

NOTE These changes represent current technological knowledge. However, these changes should not normally have an influence on equipment already placed on the market.

B) Information about the background of 'Changes

The text of this standard is based on the following documents:

FDIS	Report on voting
31/????/FDIS	31/????/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of IEC 60079 series, under the general title *Explosive atmospheres*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,

- 358 • withdrawn,
 - 359 • replaced by a revised edition, or
 - 360 • amended.
- 361 A bilingual version of this publication may be issued at a later date.
- 362

EXPLOSIVE ATMOSPHERES –**Part 7: Equipment protection
by increased safety "e"****1 Scope**

This part of IEC 60079 specifies the requirements for the design, construction, testing and marking of electrical Ex Equipment and Ex Components with Type of Protection increased safety "e" intended for use in explosive gas atmospheres.

Electrical Ex Equipment and Ex Components of Type of Protection increased safety "e" are either:

- a) Level of Protection "eb" (EPL "Mb" or "Gb"); or
- b) Level of Protection "ec" (EPL "Gc")

Level of Protection "eb" applies to Ex Equipment or Ex Components, including their connections, conductors, windings, lamps, and batteries; but not including semiconductor devices or electrolytic capacitors.

NOTE 1 The fundamental basis of "eb" is limitation of temperature, and reduced likelihood of insulation failure resulting in an arc or spark. Expected malfunctions of electronic components, such as semiconductor devices or electrolytic capacitors, can result in a failure producing excessive temperatures, or arcs and sparks.

Level of Protection "ec" applies to Ex Equipment or Ex Components, including their connections, conductors, windings, lamps, and batteries; and also including semiconductor devices and electrolytic capacitors.

NOTE 2 The use of electronic components, such as semiconductor devices or electrolytic capacitors, is permitted in Level of Protection "ec" as these are evaluated under both normal conditions and regular expected occurrences, and are not likely to result in excessive temperatures or arcs and sparks. As the requirements for separation distances are not applied to the internal construction, commercially available electronic components are generally suitable if the external separation distances comply.

The requirements of this standard apply to both Levels of Protection unless otherwise stated.

For Level of Protection "eb", this standard applies to electrical equipment where the rated voltage does not exceed 11 kV AC_{RMS} or DC.

For Level of Protection "ec", this standard applies to electrical equipment where the rated voltage does not exceed 15 kV AC_{RMS} or DC.

For voltages greater than 70.7 V_{RMS} with frequencies greater than 30 kHz, increased creepage and clearance may be required. For additional guidance, see IEC 60664-4. [MT60079-7 Note - WG32 is working to develop quantitative requirements]

NOTE 3 Short circuit currents flowing through increased safety connections of mains circuits are not considered to create a significant risk of ignition of an explosive gas atmosphere due to movement of connections as a result of mechanical stresses created by the short circuit current. Normally, the relevant industrial standards require that the effects of short time high currents on the security of connections be considered. The presence of the explosive gas atmosphere does not adversely affect the integrity of the connection.

NOTE 4 Any short term thermal excursions that occur as a result of electrical current excursions above normal rated currents, such as those that occur during the starting of motors, are not considered to create a significant risk of ignition of an explosive gas atmosphere due to the relatively short duration of the event and the convection that occurs during the event.

NOTE 5 High-voltage connections and associated wiring (above 1 kV) can be susceptible to increased partial discharge activity that could be a source of ignition. Increased spacings to earthed surfaces or other connections and provision of suitable high-voltage stress relief for the terminations are typically provided.

This standard supplements and modifies the general requirements of IEC 60079-0. Where a requirement of this standard conflicts with a requirement of IEC 60079-0, the requirement of this standard takes precedence.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60034-1, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60044-6, *Instrument transformers – Part 6: Requirements for protective current transformers for transient performance*

IEC 60061-1, *Lamp caps and holders together with gauges for the control of interchangeability and safety. Part 1: Lamp caps*

IEC 60061-2, *Lamp caps and holders together with gauges for the control of interchangeability and safety – Part 2: Lampholders*

IEC 60064, *Tungsten filament lamps for domestic and similar general lighting purposes – Performance requirements*

IEC 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-27:2008, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60068-2-42, *Environmental testing – Part 2-42: Tests – Test Kc: Sulphur dioxide test for contacts and connections*

IEC 60079-0, *Explosive atmospheres – Part 0: Equipment – General requirements*

IEC 60079-1, *Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures "d"*

IEC 60079-11, *Explosive atmospheres – Part 11: Equipment protection by intrinsic safety "i"*

IEC 60079-30-1, *Explosive atmospheres – Part 30-1: Electrical resistance trace heating – General and testing requirements*

IEC 60081, *Double-Capped Fluorescent Lamps – Performance Specifications*

IEC 60085, *Electrical insulation – Thermal evaluation and designation*

IEC 60112, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

IEC 60216-1, *Electrical insulating materials – Thermal endurance properties – Part 1: Ageing procedures and evaluation of test results*

- 443 IEC 60216-2, *Electrical insulating materials – Thermal endurance properties – Part 2:*
444 *Determination of thermal endurance properties of electrical insulating materials – Choice of test*
445 *criteria*
- 446 IEC 60228, *Conductors of insulated cables*
- 447 IEC 60238, *Edison screw lampholders*
- 448 IEC 60317-3:2004, *Specifications for particular types of winding wires – Part 3: Polyester*
449 *enamelled round copper wire, class 155*
450 + IEC 60317-3:2004/AMD1:2010
- 451 IEC 60317-8, *Specifications for particular types of winding wires – Part 8: Polyesterimide*
452 *enamelled round copper wire, class 180*
- 453 IEC 60317-13, *Specifications for particular types of winding wires – Part 13: Polyester or*
454 *polyesterimide overcoated with polyamide-imide enamelled round copper wire, class 200*
- 455 IEC 60317-46, *Specifications for particular types of winding wires – Part 46: Aromatic polyimide*
456 *enamelled round copper wire, class 240*
- 457 IEC 60400, *Lampholders for tubular fluorescent lamps and starterholders*
- 458 IEC 60432-1, *Incandescent lamps – Safety specifications – Part 1: Tungsten filament lamps for*
459 *domestic and similar general lighting purposes*
- 460 IEC 60432-2, *Incandescent lamps – Safety specifications – Part 2: Tungsten halogen lamps for*
461 *domestic and similar general lighting purposes*
- 462 IEC 60432-3, *Incandescent lamps – Safety specifications – Part 3: Tungsten halogen lamps*
463 *(non-vehicle)*
- 464 IEC 60529, *Degrees of protection provided by enclosures (IP Code)*
- 465 IEC 60598-1, *Luminaires – Part 1: General requirements and tests*
- 466 IEC 60664-1, *Insulation coordination for equipment within low-voltage systems – Part 1:*
467 *Principles, requirements and tests*
- 468 IEC 60664-4, *Insulation coordination for equipment within low-voltage systems – Part 4:*
469 *Consideration of high-frequency voltage stress*
- 470 IEC 60947-1, *Low-voltage switchgear and controlgear – Part 1: General rules*
- 471 IEC 60947-7-1, *Low-voltage switchgear and controlgear – Part 7-1: Ancillary equipment –*
472 *Terminal blocks for copper conductors*
- 473 IEC 60947-7-2, *Low-voltage switchgear and controlgear – Part 7-2: Ancillary equipment –*
474 *Protective conductor terminal blocks for copper conductors*
- 475 IEC 60947-7-4, *Low-voltage switchgear and controlgear – Part 7-4: Ancillary equipment – PCB*
476 *terminal blocks for copper conductors*
- 477 IEC 60998-2-4, *Connecting devices for low-voltage circuits for household and similar purposes*
478 *– Part 2-4: Particular requirements for twist-on connecting devices*

479 IEC 60999-1, *Connecting devices – Electrical copper conductors – Safety requirements for*
 480 *screw-type and screwless-type clamping units – Part 1: General requirements and particular*
 481 *requirements for clamping units for conductors from 0,2 mm² up to 35 mm² (included)*

482 IEC 60999-2, *Connecting devices – Electrical copper conductors – Safety requirements for*
 483 *screw-type and screwless-type clamping units – Part 2: Particular requirements for clamping*
 484 *units for conductors above 35 mm² up to 300 mm² (included)*

485 IEC 61184, *Bayonet lampholders*

486 IEC 61195, *Double-capped fluorescent lamps – Safety specifications*

487 IEC 61347-1, *Lamp controlgear – Part 1: General and safety requirements*

488 IEC 61347-2-3, *Lamp control gear – Part 2-3: Particular requirements for a.c. and/or d.c.*
 489 *supplied electronic control gear for fluorescent lamps*

490 [IEC 61439-1, Low-voltage switchgear and controlgear assemblies - Part 1: General rules](#)

491 IEC 62035, *Discharge lamps (excluding fluorescent lamps) – Safety specifications*

492 ISO 2859-1, *Sampling procedures for inspection by attributes – Part 1: Sampling schemes*
 493 *indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

494 ISO 527-2, *Plastics – Determination of tensile properties – Part 2: Test conditions for moulding*
 495 *and extrusion plastics*

496 ISO 178, *Plastics – Determination of flexural properties*

497 ANSI/UL 746B, *Polymeric Materials – Long Term Property Evaluations*

498 3 Terms and definitions

499 For the purposes of this document, the terms and definitions given in IEC 60079-0 and the following
 500 apply.

501 ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- 502 • IEC Electropedia: available at <http://www.electropedia.org/>
- 503 • ISO Online browsing platform: available at <http://www.iso.org/obp>

504 3.1 505 comparable converter

506 [converter where the losses in the motor supplied by the converter are not higher than the losses that](#)
 507 [would have occurred if the motor were used with the specific converter that was used during the type](#)
 508 [test](#)

509 [Note 1 to Entry: This converter is similar with respect to the output voltage, output current, and switching frequency](#)
 510 [specifications so the machine limiting temperatures, for maximum surface temperature and material thermal stability, are not](#)
 511 [exceeded.](#)

512 [Note 2 to Entry: Additional information on determining comparability is given in Annex L.](#)

Deleted: a converter where the losses in the converter-supplied motor are not higher than the losses that would have occurred if the motor were used with the specific converter that was used during the type test[†]

Deleted: 1

3.2**duty type (motor)**

continuous, short-time or periodic duty, comprising one or more loads remaining constant for the duration specified, or a non-periodic duty in which generally load and speed vary within the permissible operating range

Note 1 to entry: These include duty types S1 to S10, as defined in IEC 60034-1.

3.3**ferrule**

metal tube crimped over fine-stranded conductor to secure it within a terminal usually with electrical insulation protecting any exposed portion of the wire not completely inside the terminal post

Deleted: wire

3.4**increased safety "e"**

Type of Protection applied to Ex Equipment or Ex Components in which additional measures are applied so as to give increased security against the possibility of excessive temperatures and against the occurrence of arcs and sparks

3.5**initial starting current****I_A**

highest I_{RMS} value of current drawn by an AC motor when at rest or by an AC magnet with its armature clamped in the position of maximum air gap when supplied at rated voltage and rated frequency

Note 1 to entry: Transient phenomena are ignored.

3.6**Light Emitting Diode****LED**

solid state device embodying a p-n junction, emitting optical radiation when excited by an electric current

3.7**LED module**

light source having no cap, incorporating one or more LED package(s) on a printed circuit board, and possibly including one or more of the following: electrical, optical, mechanical, and thermal components, interfaces, and controlgear

3.8**LED package**

single electrical component encapsulating principally one or more LEDs, possibly with optical elements and thermal, mechanical, and electrical interfaces

Note 1 to entry: The component does not include the control unit of the controlgear, does not include a cap, and is not connected directly to the supply voltage.

Note 2 to entry: An LED package is a discrete component and part of the LED module or LED lamp.

3.9**Low-voltage switchgear and controlgear assemblies****industrial control equipment**

combination of one or more low-voltage switchgear and controlgear and associated equipment for controlling, measuring, signalling, protecting and regulating, with all internal electrical and mechanical connections and structural components.

3.10**normal service**

<machines> continuous operation at the nameplate rating (or set of ratings) generally including starting conditions

568 Note 1 to entry: For motors of duty type S1, S2, S6 or S9, normal service for electrical machines for Level of Protection "ec"
569 are assumed to be rated full-load steady conditions. For motors of duty types S3, S4, S5, S7, S8 or S10, normal service for
570 Level of Protection "ec" includes starting.

571 **3.11**
572 **rated dynamic current**
573 **I_{dyn}**

574 peak value of the current, the dynamic effect of which the electrical equipment can sustain without
575 damage

576 **3.12**
577 **rated short-time thermal current**
578 **I_{th}**

579 RMS value of the current required to heat up the conductor within 1 s from the temperature reached in
580 rated service at the maximum ambient temperature to a temperature not exceeding the limiting
581 temperature

582 **3.13**
583 **resistance-heating applications**

584 **3.13.1**
585 **resistance-heating**

586 utilization of electric resistance-heating devices, units and any associated controls (other than
587 electrical trace heating systems)

588 Note 1 to entry: Electric trace heating systems are addressed by IEC 60079-30-1.

589 **3.13.2**
590 **resistance-heating device**

591 part of a resistance heating unit consisting of one or more heating resistors, typically composed of
592 metallic conductors or an electrically conductive material suitably insulated and protected

593 Note 1 to entry: An example of a resistance heating device covered by this standard is an anti-condensation heater.

594 **3.13.3**
595 **resistance-heating unit**

596 equipment consisting of an assembly of one or more resistance heating devices associated with any
597 safety devices necessary to ensure that the limiting temperature is not exceeded

598 Note 1 to entry: It is not intended that the safety devices necessary to ensure that the limiting temperature is not exceeded
599 should have Type of Protection "e" or any Type of Protection when they are located outside the hazardous area.

600 **3.13.4**
601 **stabilized design**

602 design where the temperature of the resistance-heating device or resistance-heating unit will, by
603 design and use, stabilize below the limiting temperature, under the most unfavourable conditions,
604 without the need for a safety device to limit the temperature

605 **3.13.5**
606 **temperature self-limiting characteristic**

607 characteristic whereby the thermal output of a resistance-heating device at its rated voltage decreases
608 as the temperature of its surroundings increases until the device reaches a temperature at which its
609 thermal output is reduced to a value at which there is no further rise in temperature

610 Note 1 to entry: The temperature of the surface of the element is then effectively that of its surroundings.

611 **3.13.6**
612 **workpiece**

613 object to which a resistance-heating device or resistance-heating unit is applied

3.14**pulse frequency** **f_p**

frequency, resulting from the average modulation cycle duration, which characterizes the lowest non-controllable frequency lobe of the phase-to-phase voltage spectrum

3.15**semiconductor device**

device, the essential electric characteristics of which are due to the flow of charge carriers within one or more semiconductor materials

[SOURCE: 151-13-63]

3.16**short-circuit current** **I_{sc}**

maximum RMS value of the short-circuit current to which the equipment may be subjected in service

Note 1 to entry: This maximum value is recorded in the documentation prepared according to IEC 60079-0.

3.17**starting current ratio** **I_A/I_N**

ratio between initial starting current I_A and rated current I_N

3.18**stator winding**

stationary winding in an electric machine, either for rotary or linear motion

3.19**switching frequency** **f_{sw}**

number of switching events of one semiconductor within one second

Note 1 to entry: It determines, together with the selected pulse pattern and the converter topology, the lowest frequency of non-controllable harmonics or inter-harmonics at the IPC (in-plant point of coupling) or the motor.

Note 2 to entry: To turn on and turn off the semiconductor's switch are separate switching events. Thus, the switching frequency of a two level converter is two times the pulse frequency (also called the carrier frequency) of the phase-to-phase voltage for modulation that uses continuous switching and about 1,33 times the pulse frequency of the phase-to-phase voltage for modulation that uses discontinuous switching.

3.20**terminal**

conductive part of a device provided to mechanically make an electrical connection to external or internal circuits

3.21**time** **t_E**

time, in seconds, taken for a rotor or stator winding of an AC machine, when carrying the initial starting current I_A , to be heated up to the limiting temperature from the temperature reached under the worst case, rated service conditions at the maximum ambient temperature (see Figure A.1)

Deleted: point of interconnection of an electric circuit element, a circuit, or a network with other electric circuit elements, electric circuits or networks¶

Deleted: n

Deleted: AC

Deleted: in

3.22**trace heater**

device designed for the purpose of producing heat on the principle of electrical resistance and typically composed of one or more metallic conductors or an electrically conductive material suitably electrically insulated and protected

Note 1 to entry: For additional information on trace heaters, see IEC 60079-30-1.

4 Construction requirements

4.1 Level of Protection

Electrical equipment with Type of Protection increased safety "e" shall be one of the following:

- Level of Protection "eb" (EPL "Mb" or "Gb"); or
- Level of Protection "ec" (EPL "Gc").

The requirements of this clause apply, unless otherwise stated in Clause 5, to all Ex Equipment and Ex Components with Type of Protection "e".

Ex Equipment and Ex Components evaluated as Level of Protection "ec" may include manually operated arcing or sparking components under the following conditions:

- located within an enclosure that cannot be opened without the use of a tool such as a key, screwdriver, or wrench; and
- cannot be accessed or operated without opening the enclosure

4.2 Electrical connections

4.2.1 General

Electrical connections intended to be terminated internal to the equipment enclosures are subdivided into those for field wiring connections, 4.2.2, and for factory connections, 4.2.3, and into permanent types and reconnectable / rewirable types for convenience in detailing the appropriate requirements.

External earthing and equipotential bonding connections shall comply with the requirements for field wiring connections, 4.2.2.

Each type shall, as applicable:

- a) be constructed in such a way that the conductors cannot slip out from their intended location during tightening of a screw or after insertion;
 - b) provide a means to avoid loosening of the connection in service;
 - c) be such that contact is assured without damage to the intended conductors such that would impair the ability of the conductors to fulfil their function;
 - d) provide a positive compression force to assure contact pressure in service;
 - e) be constructed in such a way that the contact they assure is not appreciably impaired by temperature changes occurring in normal service;
 - f) provide contact pressure that does not depend on the structural integrity of insulating materials except;
 - as permitted by the earth continuity test of IEC 60079-0 or
 - for printed circuit board material (See 4.5.2)
- [-for Level of Protection "ec" only, PCB terminal blocks for copper conductors according to IEC 60947-7-4.](#)
- NOTE Printed circuit boards are often inserted into card edge connectors where the contact pressure relies on the stability of the insulating material
- g) not be specified to accommodate more than one individual conductor in a clamping point unless specifically designed and assessed for doing so;
 - h) if intended for stranded conductors, employ a means to protect the conductors and distribute the contact pressure evenly. The method of applying contact pressure shall be capable, on installation, of reliably forming the stranded conductor into an effectively solid shape that does not subsequently change in service. Alternatively, the method of applying

the contact pressure should be such that it is designed to accommodate any settlement of the strands in service;

i) for screw connections, have a torque value specified by the manufacturer;

j) for screwless connections intended for class 5 and/or class 6 fine-stranded conductors according to IEC 60228, the instructions shall specify that the fine-stranded conductor shall be equipped with a ferrule (See 9.3.2 c) or the termination shall have a method to open the clamping mechanism so that the conductors are not damaged during the installation of the conductor.

NOTE 1 The use of aluminium wire can cause difficulties by compromising critical creepage and clearance distances when anti-oxidant materials are applied. The connection of aluminium wire to terminals is typically by the use of suitable bi-metallic connection devices providing a copper connection to the terminal.

NOTE 2 Special precautions against vibration and mechanical shock are often applied to reduce the risk of loosening.

NOTE 3 Electrolytic corrosion where ferrous materials are used can occur. Guidance on limitation of corrosion based on the limitation of electrochemical potential between dissimilar metals can be found in IEC TR 60943.

NOTE 4 The limiting temperature of the insulation of terminal blocks and accessories will usually be based on the limiting temperature of the insulation in accordance with item a) of 4.7.2 but the limiting temperature allocated to the terminal when used in equipment will also depend on the maximum cable insulation temperature rating of the cable which is to be connected.

4.2.2 Field wiring connections

4.2.2.1 General

Terminals for field wiring shall be dimensioned to allow the effective connection of conductors of cross-section equal to at least that required for the rated current of the electrical equipment.

Connections shall be located in a position so that when required to be inspected in service they are reasonably accessible.

The number, size, and type of conductors that can be safely connected shall be specified in the documentation prepared in accordance with IEC 60079-0.

NOTE 1 The "type of conductor" includes features such as conductor material and stranding.

NOTE 2 Some types of cables, such as those used to conform to EMC requirements, include multiple earthing conductors. Facilities are sometimes required for the termination of more earthing conductors than would normally be expected.

4.2.2.2 Connections made using terminal blocks or similar clamping units

These requirements apply to terminal blocks or similar clamping units of the types defined by IEC 60947-7-1, IEC 60947-7-2, IEC 60947-7-3, IEC 60947-7-4, IEC 60999-1, or IEC 60999-2.

NOTE It is not a requirement of this standard that conformity to IEC 60947-7-1, IEC 60947-7-2, IEC 60947-7-3, IEC 60947-7-4, IEC 60999-1, or IEC 60999-2 needs to be verified.

Such terminals are intended for the connection of copper conductors with the insulation locally removed and without the addition of intermediate parts other than those replicating the form of a bare conductor, such as a ferrule.

Terminals in Level of Protection "eb" shall be subject to the terminal insulation material tests of 6.11.

Fused terminal blocks defined by IEC 60947-7-3 are only suitable for Level of Protection "ec" and shall also comply with requirements of 5.10.

Terminals shall be capable of being fixed in their mountings.

For Ex Component terminals in Level of Protection "eb", the temperature rise of the conductor bar shall not exceed 40 K at a reference current of 110 % of rated current according to the method of the temperature-rise test of IEC 60947-7-1.

NOTE 1 The 40 K rise referred to in 4.2.2.2 is only for the Ex Component evaluation of terminals and is not determined in the actual application of the terminal, where a rise of more or less than 40 K may be observed. The reference current is used for the comparison of terminals to allow the "worst case" to be determined. See 8.2g), 6.8 and Annex E.

NOTE 2 This test relates to the absolute maximum current rating of the terminal when tested without any enclosure. For practical purposes, when terminals are used in multiples within enclosures, it will be necessary to establish reduced current ratings according to the particular circumstances. See 5.7, 6.8 and Annex E.

Terminals for connecting conductors of rated cross-section not exceeding 35 mm² (2 AWG) shall also be suitable for the effective connection of conductors at least two ISO wire sizes smaller, in accordance with Annex F, if not otherwise specified in the certificate.

4.2.2.3 Integral field wiring connection facilities

Integral field wiring connection facilities shall meet the requirements of 4.2.2.2, as applicable.

NOTE 1 The connection facilities for Ex Equipment or Ex Components employing other types of protection, such as flameproof enclosure "d", permit installation using increased safety "e" as the connection method.

NOTE 2 The 40 K rise referred to in 4.2.2.2 is only for the Ex Component evaluation of terminals and is not determined in the actual application of the terminal, where a rise of more or less than 40 K may be observed.

4.2.2.4 Connections designed to be used with cable lugs and similar devices

Such connections shall be fixed in their mountings.

Terminals shall meet the requirements of 4.2.2.1.

Terminals in Level of Protection "eb" shall be subject to the terminal insulation material tests of 6.11.

A means of securing the cable or conductors to prevent rotation or movement shall be provided to avoid either loosening or compromising creepage and clearance. Alternatively, the certificate number shall include the "X" suffix in accordance with the marking requirements of IEC 60079-0 and the Specific Conditions of Use listed on the certificate shall detail the provisions for securing the cable or conductors to avoid compromising creepage and clearance, and the provisions to avoid loosening of the connections. If the option to use marking instead of the "X" suffix is employed in accordance with IEC 60079-0, this marking may appear on either the exterior or the interior of the connection compartment.

NOTE Conductors with rated cross-section greater than 35 mm² can provide sufficient rigidity to avoid compromising creepage and clearance.

4.2.2.5 Connections using permanent arrangements

These connections are typically individual conductors (flying leads) that are intended to be terminated during installation using appropriate connection methods, see 4.2.1. Either a means of fixing the completed connections to a suitable location is to be provided or the completed connections are to be provided with means of reliably insulating them to the requirements of this standard.

If the method of connection is by soldering, a method of providing mechanical support of the completed connection, in addition to the solder, shall be provided. The mechanical support of the connection shall not be permitted to rely solely on the solder.

NOTE The intent of the mechanical support is to avoid mechanical stresses being transferred to the electrical connection.

4.2.3 Factory connections

4.2.3.1 General

Factory connections shall be either fixed in a specific location or be provided with means of meeting the creepage and clearance requirements of this standard.

Any of the connection methods suitable for use as field wiring connections may be used for a factory connection, except in this case, the terminal insulation material tests of 6.11 need not be conducted for either Level of Protection “eb” or “ec”.

NOTE The requirements for the thermal stability of the insulating material are given in 4.5.

4.2.3.2 Twist-on connectors for Level of Protection “ec”

In addition to the connection methods suitable for field wiring connections, twist-on connecting devices meeting the requirements of IEC 60998-2-4 may also be used for factory connections in Level of Protection “ec”.

4.2.3.3 Permanent connections

Permanent connections shall only be made by:

- a) crimping;
- b) brazing;
- c) welding;
- d) soldering, with mechanical support of the completed connection, in addition to the solder, provided;
- e) In Level of Protection “ec”, soldering of printed circuit board mounted components, including surface-mount and through-hole mount components, **without** additional mechanical support
- f) In Level of Protection “ec”, soldering of single conductors that terminate at both ends on the same printed circuit board using surface-mounting or through-hole mounting **without** additional mechanical support; or
- g) In Level of Protection “ec”, soldering multiple conductors physically connected in a group to a printed circuit board at only one end, using either surface-mounting or through-hole mounting, and not subject to mechanical stresses due to flexing in normal operation, **without** additional mechanical support.

NOTE 1 The intent of the mechanical support is to avoid mechanical stresses being transferred to the electrical connection.

NOTE 2 The process commonly referred to as “silver soldering” is considered “brazing”.

NOTE 3 Typical examples of conductors physically connected in a group are ribbon cables, flex circuits, or standard round cables where the construction of the cable is such that a single conductor cannot be pulled out.

4.2.3.4 Pluggable connections for Level of Protection “eb”

These connections are designed to be readily connected or disconnected during assembly, maintenance, or repair.

NOTE 1 Typical examples are plug-in components, and card edge connectors

Pluggable connections in Level of Protection “eb” shall provide the following:

- a) each connection shall employ at least two areas of contact where the loss of one area of contact does not compromise the effectiveness of the other;
- b) the connection shall be provided with an interlock to prevent separation when energized or shall be marked in accordance with item a) of Table 19. For small items, adjacent marking can be provided; and

Deleted: or

c) Connection secureness using either of the following:

- each connection or group of connections shall be provided with a mechanical retaining device, which, excluding internal friction, provides a force resisting separation of at least 30 N with the force applied gradually near the centre of the component. ~~or~~

NOTE 2 It is the intent that the effectiveness of the mechanical retention for Level of Protection "eb" be evaluated by test due to the increased risk of ignition due to separation of contacts in equipment of EPL Gb.

- for a connecting component relying on friction to remain in place and not attached in any way outside of the connection points, take the numerical value of 200 times the mass (in kg) of the component (not including the mass of any attached conductors), and apply it (in Newtons) as a tensile force, with the force applied gradually near the centre of the component. In this case, a mechanical retaining device is not required.

Deleted: Where a group of individual connections is mechanically linked and the separable component has a mass of more than 0,25 kg or carries more than 10 conductors, special consideration shall be given to the security of the connection;

Deleted: 3

4.2.3.5 Pluggable connections for Level of Protection "ec"

These connections are designed to be readily connected or disconnected during assembly, maintenance, or repair.

NOTE Typical examples are connectors, plug-in components, and card edge connectors

Sockets of pluggable connection for Level of Protection "ec", which in normal operation do not have a plug inserted and which are intended to be used only for maintenance and repairing, are evaluated without the mating part inserted.

Pluggable connections in Level of Protection "ec" shall provide connection secureness using either of the following:

- a) Each connection or group of connections shall be provided with a mechanical retaining device, excluding internal friction, or shall provide a force resisting separation of at least 15 N with the separating force applied gradually near the centre of the component. ~~or~~

A means to evaluate the effectiveness of the mechanical retention is by the 15 N test described herein.

- b) For a connecting component relying on friction to remain in place and not attached in any way outside of the connection points, take the numerical value of 100 times the mass (in kg) of the component (not including the mass of any attached conductors), and apply it (in Newtons) as a tensile force, with the force applied gradually near the centre of the component. In this case, a mechanical retaining device is not required.

Deleted: Where a group of individual connections is mechanically linked and the separable component with a mass of more than 0,25 kg or carries more than 10 conductors, special consideration shall be given to the security of the connection....

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4.2.3.6 Pluggable terminal bridging connections

These connections are intended to be made one-time only and not connected or disconnected during maintenance or repair.

For Level of Protection "eb", a terminal bridging connector shall have a separating force (in Newtons) that is calculated by taking the numerical value of ~~200~~ times the mass (in kg) of the component, and applying it (in Newtons) as a tensile force, with the force applied gradually near the centre of the terminal bridging connector.

For Level of Protection "ec", a terminal bridging connector shall have a separating force in Newtons that is calculated by taking the numerical value of 100 times the mass (in kg) of the component, and applying it (in Newtons) as a tensile force, with the force applied gradually near the centre of the terminal bridging connector.

4.2.4 External plug and socket connections for field wiring connection

Plug and socket connections, where the flange plug / socket forms part of the wall of the enclosure, and the mating plug / socket is intended to be inserted externally, shall comply with the supplementary requirements of this sub-clause. The connections of the mating portion, if provided un-terminated, are considered field wiring.

Plugs and sockets for field wiring connections either:

- Between one piece of electrical equipment and another piece of electrical equipment (by means of a cable assembly involving plugs / sockets on both ends; or a plug / socket on one end and un-terminated cable on the other), or
- Between the fixed installation and a piece of electrical equipment (by means of a cable assembly involving a socket on the equipment end and un-terminated cable on the fixed installation end),

shall comply with item a), b) or c) as follows:

- a) they shall be interlocked mechanically or electrically, or otherwise designed so that they cannot be separated when the contacts are energized and the contacts cannot be energized when the plug and socket are separated;
- b) the equipment marked with the CONNECT / DISCONNECT marking as required by item a) of Table 19, and for:
 - Level of Protection “ec”:
 - fixed together by means of a fastener in accordance with the general fastener requirements of IEC 60079-0;
 - interconnected by means of two (2) or more engaged threads; or
 - provided with a mechanical retaining device, other than friction, that ensures a minimum separation force of 30 N with the separating force applied gradually near the centre of the plug or socket.
 - Level of Protection “eb”, fixed together by means of a special fastener according to IEC 60079-0.
- c) where they cannot be de-energized before connection or disconnection according to b) above because they are connected to a battery, the marking shall state the separation warning required by item j) of Table 19.

Provision shall be made for the fixed part of a plug and socket connector to maintain the degree of protection (IP) of the enclosure on which it is mounted, even when the mating plug or socket has been removed. If the degree of protection (IP) is effectively reduced by accumulation of dust or water, provision shall also be made for maintaining an appropriate degree of protection (IP) for the plug or socket.

4.3 Insulation coordination

4.3.1 Environmental conditions

The conditions of the micro-environment for the insulation shall be taken into account. They depend primarily on the conditions of the macro-environment in which the equipment is located and, in many cases, the environments are identical. However, the micro-environment can be better or worse than the macro-environment where, for example, enclosures, heating, ventilation or dust influence the micro-environment.

For the evaluation of clearance and creepage distances according to this standard, the worst case micro-environment is taken into consideration. Permitted methods to improve the micro-environment separate from controlling the macro-environment are identified, for example, coatings, and shall be taken into account when employed.

NOTE 1 Protection by enclosures provided according to the degrees of protection specified in IEC 60529 may increase the humidity of the micro-environment [as per IEC 60664-5].

NOTE 2 The main environmental parameters are as follows [as per IEC 60664-5]:

- for clearances
 - air pressure,
 - temperature, if it has a wide variation;
- for creepage distances
 - air pressure,
 - pollution,

- 945 – relative humidity,
- 946 – condensation;
- 947 – for solid insulation
- 948 – temperature,
- 949 – relative humidity

950 4.3.2 Clearances

951 4.3.2.1 General

952 Clearances shall be determined as a function of the working voltage. Where the equipment is intended
 953 for more than one rated voltage or for a range of rated voltages, the value of working voltage to be
 954 used shall be based on the highest value of rated voltage. In determining the clearances, Examples 1
 955 to 11 (inclusive) in Figure 3 illustrate the features to be taken into account and the appropriate
 956 clearances.

957 Spacings at wiring terminals shall be evaluated with and without the conductor to determine the
 958 minimum clearance under worst case conditions. Conductor arrangement shall be as specified by the
 959 manufacturer.

960 NOTE 1 The conductor arrangement by the manufacturer includes conductor sizes, conductor stripping dimensions,
 961 conductor ferrule usage, maximum screw torque, etc.

962 NOTE 2 A wiring terminal supplied with the conductor clamping arrangement fully open can present the worst case condition
 963 for spacings.

964 4.3.2.2 Clearances for Level of Protection “eb”

965 Clearances between bare conductive parts at different potentials shall be as given in Table 2 with a
 966 minimum value for field wiring connections of 3 mm.

967 4.3.2.3 Clearances for Level of Protection “ec”

968 Clearances between bare conductive parts at different potentials shall be designed in accordance with
 969 Figure 1, with a minimum value for field wiring connections of 1,5 mm.

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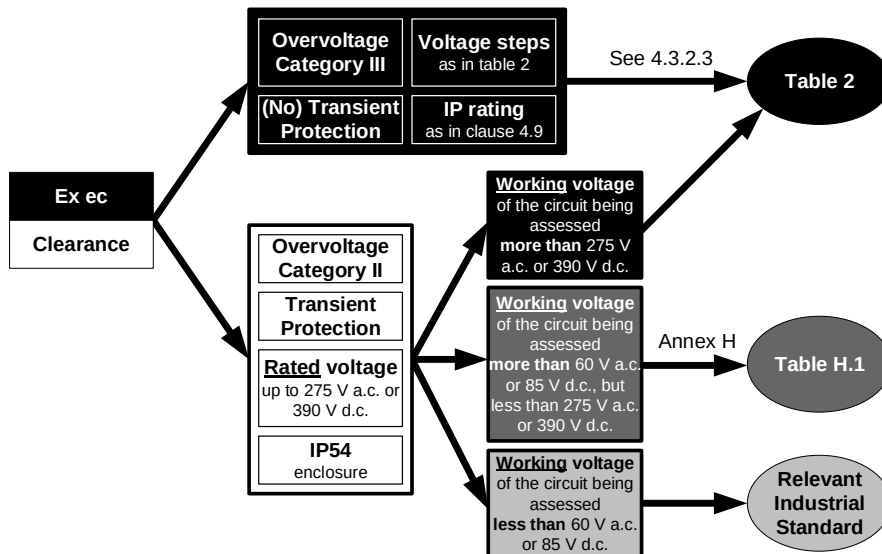


Figure 1 – Clearance for Level of Protection “ec”**4.3.3 Creepage distances****4.3.3.1 General**

Spacings at wiring terminals shall be evaluated with and without the conductor to determine the minimum creepage distance.

Table 1 gives the grouping of electrical insulating materials according to the comparative tracking index (CTI) determined in accordance with IEC 60112. Inorganic insulating materials, for example glass and ceramics, do not track and need not therefore be subjected to the determination of the CTI. They are conventionally classified in material group I.

The grouping given in Table 1 is applied to insulating parts without ribs or grooves. If there are ribs or grooves in accordance with 4.3.3.2, or 4.3.3.3, as applicable, the minimum permissible creepage distances for working voltages up to 1 100 V shall be based on the next higher material group, for example material group I instead of material group II.

NOTE 1 The material groups are identical with those given in IEC 60664-1.

Table 1 – Tracking resistance of insulating materials

Material group	Comparative tracking index (CTI)
I	$600 \leq \text{CTI}$
II	$400 \leq \text{CTI} < 600$
IIIa	$175 \leq \text{CTI} < 400$
IIIb	$100 \leq \text{CTI} < 175$

4.3.3.2 Creepage distances for Level of Protection “eb”

Creepage distances between bare conductive parts at different potentials shall be as given in Table 2, with a minimum value for field wiring connections of 3 mm and shall be determined based on the working voltage determined as a function of the rated voltage of the equipment. In determining the creepage distance, Figure 3 illustrates the features to be taken into account and the appropriate creepage distance. The value of dimension 'X' is 2,5 mm.

The effects of ribs and grooves may be taken into account provided that:

- ribs on the surface are at least 2,5 mm high and of a thickness appropriate to the mechanical strength of the material with a minimum value of 1,0 mm;
- grooves on the surface are at least 2,5 mm deep and at least 2,5 mm wide. If the associated clearance is less than 3 mm, the minimum groove width may be reduced to 1,5 mm.

Projections above or depressions below the surface are considered as being either ribs or grooves, irrespective of their geometric form.

Cement or compound used as part of the electrical insulation system is considered to be a solid electrical insulating material.

4.3.3.3 Creepage distances for Level of Protection “ec”

Creepage distances between bare conductive parts at different potentials shall be designed in accordance with Figure 2, with a minimum value for field wiring connections of 1,5 mm and shall be based on the working voltage determined as a function of the rated voltage of the equipment.

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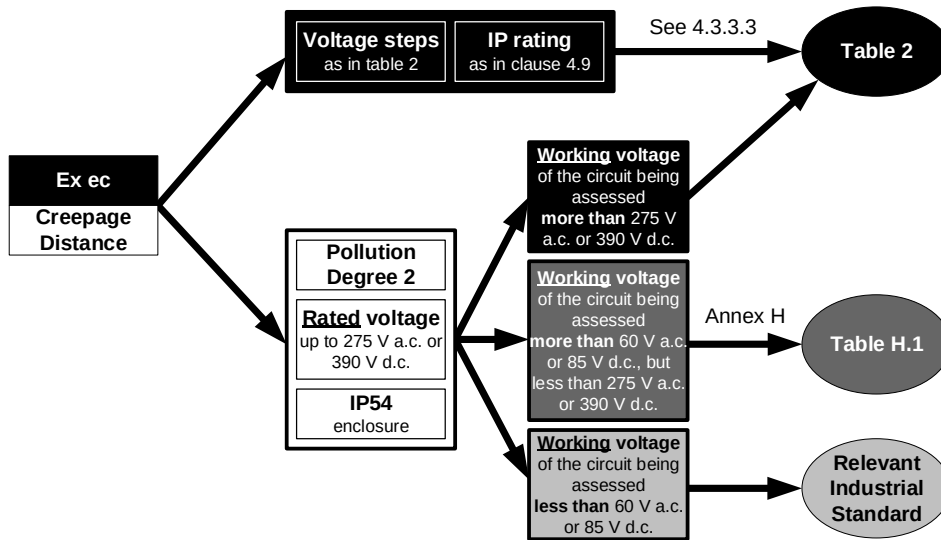


Figure 2 – Creepage distance for Level of Protection “ec”

In determining the creepage distance, Figure 3 illustrates the features to be taken into account and the appropriate creepage distance. The value of dimension 'X' is 1,5 mm.

The effects of ribs and grooves may be taken into account provided that:

- ribs on the surface are at least 1,5 mm high and of a thickness appropriate to the mechanical strength of the material with a minimum value of 0,4 mm;
- grooves on the surface are at least 1,5 mm deep and at least 1,5 mm wide.

Projections above or depressions below the surface are considered as being either ribs or grooves, irrespective of their geometric form.

Cement or compound used as part of the electrical insulation system is considered to be a solid electrical insulating material.

4.3.4 Separation distances

1025

Table 2 – Minimum Creepage distances, clearances and separations

Voltage (see a and b) <i>U</i> AC _{RMS} or DC V	Minimum creepage distance mm								Clearance mm		Distance <u>under...</u> mm		
	Material group										▼		
	I		II		IIIa		IIIb				Coating ^a	Type 1 Coating ^a	Type 2 Coating ^a
	"eb"	"ec"	"eb"	"ec"	"eb"	"ec"	"eb"	"ec"	"eb"	"ec"	"ec"	"ec"	"ec"
≤10 (see c)	1,6	.. ^d	1,6	.. ^d	1,6	.. ^d	-	.. ^d	1,6	.. ^d	.. ^d	.. ^d	.. ^d
≤ 12,5	1,6	.. ^d	1,6	.. ^d	1,6	.. ^d	-	.. ^d	1,6	.. ^d	.. ^d	.. ^d	.. ^d
≤ 16	1,6	1,1	1,6	1,1	1,6	1,1	-	1,1	1,6	0,8	0,3	0,1	0,1
≤ 20	1,6	1,2	1,6	1,2	1,6	1,2	-	1,2	1,6	0,8	0,3	0,11	0,1
≤ 25	1,7	1,25	1,7	1,25	1,7	1,25	-	1,25	1,7	0,8	0,3	0,125	0,1
≤ 32	1,8	1,3	1,8	1,3	1,8	1,3	-	1,3	1,8	0,8	0,3	0,14	0,1
≤ 40	1,9	1,4	2,4	1,6	3,0	1,8	-	1,8	1,9	0,8	0,6	0,16	0,1
≤ 50	2,1	1,5	2,6	1,7	3,4	1,9	-	1,9	2,1	0,8	0,6	0,18	0,1
≤ 63	2,1	1,6	2,6	1,8	3,4	2	-	2	2,1	0,8	0,6	0,25	0,2
≤ 80	2,2	1,7	2,8	1,9	3,6	2,1	-	2,1	2,2	0,8	0,8	0,25	0,2
≤ 100	2,4	1,8	3,0	2	3,8	2,2	-	2,2	2,4	0,8	0,8	0,25	0,2
≤ 125	2,5	1,9	3,2	2,1	4,0	2,4	-	2,4	2,5	1	0,8	0,75	0,45
≤ 160	3,2	2	4,0	2,2	5,0	2,5	-	2,5	3,2	1,5	1,1	0,75	0,45
≤ 200	4,0	2,5	5,0	2,8	6,3	3,2	-	3,2	4,0	2	1,7	1,5	1,2
≤ 250	5,0	3,2	6,3	3,6	8,0	4	-	4	5,0	2,5	1,7	1,5	1,2
≤ 320	6,3	4	8,0	4,5	10,0	5	-	5	6,0	3	2,4	1,5	1,2
≤ 400	8,0	5	10,0	5,6	12,5	6,3	-	6,3	6,0	4	2,4	1,92	1,5
≤ 500	10	6,3	12,5	7,1	16	8	-	8	8,0	5	2,4	2,33	1,5
≤ 630	12	8	16	9	20	10	-	10	10	5,5	2,9	2,75	1,5
≤ 800	16	10	20	11	25	12,5	-	-	12	7	4	4,0	3
≤ 1 000	20	11	25	11	32	13	-	-	14	8	5,8	4,0	3
≤ 1 250	22	12	26	12	32	15	-	-	18	10	-	-	-
≤ 1 600	23	13	27	13	32	17	-	-	20	12	-	-	-
≤ 2 000	25	14	28	14	32	20	-	-	23	14	-	-	-
≤ 2 500	32	18	36	18	40	25	-	-	29	18	-	-	-
≤ 3 200	40	22	45	22	50	32	-	-	36	22	-	-	-
≤ 4 000	50	28	56	28	63	40	-	-	44	28	-	-	-
≤ 5 000	63	36	71	36	80	50	-	-	50	36	-	-	-
≤ 6 300	80	45	90	45	100	63	-	-	60	45	-	-	-
≤ 8 000	100	56	110	56	125	80	-	-	80	56	-	-	-
≤ 10 000	125	71	140	71	160	100	-	-	100	70	-	-	-
≤ 12 500	-	90	-	90	-	125	-	-	-	89	-	-	-
≤ 13 640	-	98	-	98	-	138	-	-	-	97	-	-	-

^a When determining the required values for creepage and clearance, the working voltage may be higher than the voltage in Table 2 by a factor of 1,1.

NOTE The factor of 1,1 recognizes that at many places in a circuit, the working voltage equals the rated voltage and that there are a number of rated voltages in common use that can be accommodated by the 1,1 factor.

^b The creepage distance and clearance values shown already take into account a maximum supply voltage tolerance of ±10 %. Therefore it is not necessary to further consider supply voltage fluctuations when determining which voltage value from Table 2 to use.

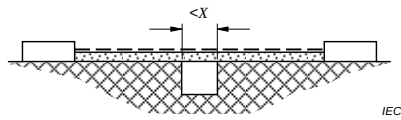
^c At 10 V and below, the value of CTI is not relevant and materials not meeting the requirement for material group IIIb may be acceptable.

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^d For Level of Protection "ec", industrial spacings apply for 10 V and 12.5 V.
^e The distances under coating shown are permitted for printed circuit boards in Level of Protection "ec" as described in 4.4.

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Example 1

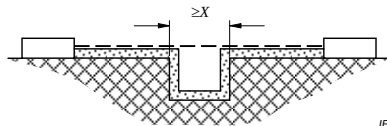


IEC

Condition: Path under consideration includes a parallel- or converging-sided groove of any depth with a width less than X mm.
 Rule: Creepage distance and clearance are measured directly across the groove as shown.

--- 1 clearance 2 creepage distance

Example 2

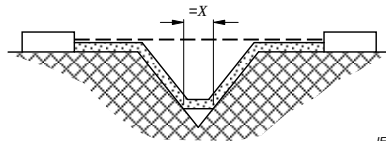


IEC

Condition: Path under consideration includes a parallel-sided groove of any depth d equal to or more than X mm.
 Rule: Clearance is the 'line of sight' distance. Creepage path follows the contour of the groove.

--- 1 clearance 2 creepage distance

Example 3

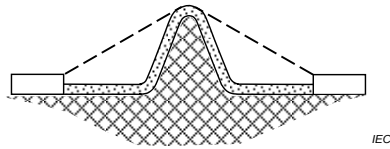


IEC

Condition: Path under consideration includes a V-shaped groove with a width greater than X mm.
 Rule: Clearance is the 'line of sight' distance. Creepage path follows the contour of the groove but 'short circuits' the bottom of the groove by X mm link.

--- 1 clearance 2 creepage distance

Example 4

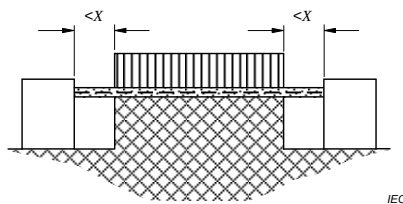


Condition: Path under consideration includes a rib.

Rule: Clearance is the shortest direct air path over the top of the rib. Creepage path follows the contour of the rib.

--- 1 clearance 2 creepage distance

Example 5

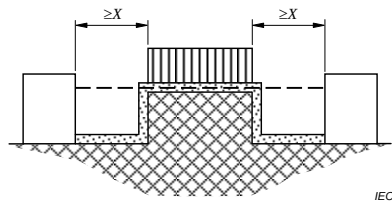


Condition: Path under consideration includes an uncemented joint with groove less than X mm wide on each side.

Rule: Creepage and clearance path is the 'line of sight' distance shown.

--- 1 clearance 2 creepage distance

Example 6

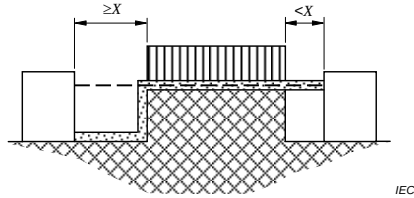


Condition: Path under consideration includes an uncemented joint with grooves equal to or more than X mm wide on each side.

Rule: Clearance is the 'line of sight' distance. Creepage path follows the contour of the grooves.

--- 1 clearance 2 creepage distance

Example 7

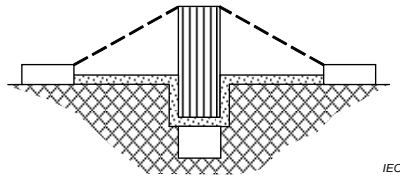


Condition: Path under consideration includes an uncemented joint with a groove on one side less than X mm wide and the groove on the other side equal to or more than X mm wide.

Rule: Clearance and creepage paths are as shown.

----- 1 clearance 2 creepage distance

Example 8

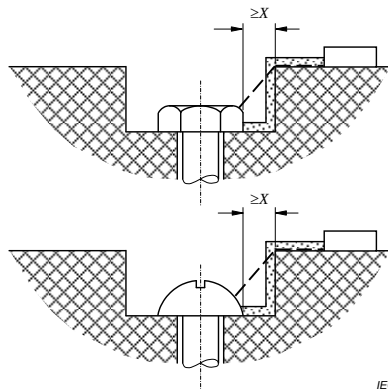


Condition: Creepage distance through uncemented joint is less than creepage distance over barrier.

Rule: Clearance is the shortest direct air path over the top of the barrier.

----- 1 clearance 2 creepage distance

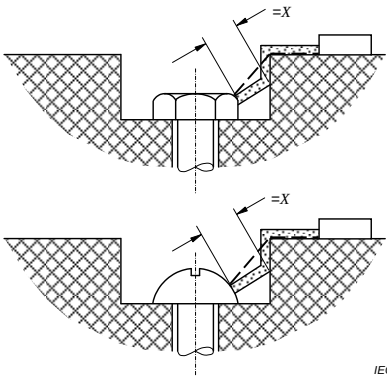
Example 9



Gap between head of screw and wall of recess wide enough to be taken into account.

----- 1 clearance 2 creepage distance

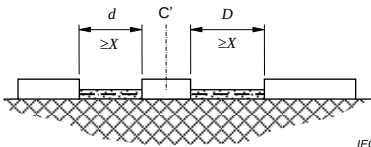
Example 10



Gap between head of screw and wall of recess too narrow to be taken into account.
Measurement of creepage distance is from screw to wall when the distance is equal to X mm.

----- 1 clearance [hatched] 2 creepage distance

Example 11



Clearance is the distance $d + D$
Creepage distance is also $d + D$
C' conductive part interposed in the insulating path between the conductors

----- 1 clearance [hatched] 2 creepage distance

Figure 3 – Determination of creepage distances and clearances

NOTE The examples in Figure 3 are identical with those given in IEC 60664-1.

4.4 Printed circuit boards with coating, Level of Protection “ec”

Table 2 and Table H.1 both provide for a reduced separation distance where the tracks and components on a printed circuit board are sealed from the atmosphere with a coating.

In both Table 2 and Table H.1, the column headed “coating” applies to any coating which may be applied to the circuit board.

The coating shall adhere to the conductive parts and the insulating material. Coating may be applied by spraying, dip coating, brushing, vacuum impregnating, or other methods which achieve an effective, lasting, unbroken seal.

Deleted: A solder mask alone is not considered as a coating, but may be accepted as one of the two coats when an additional coat is applied, provided the solder mask is not damaged during soldering.†

If the coating is of a type that meets the requirements of a Type 1 or a Type 2 coating, in accordance with the requirements of IEC 60664-3, it will provide a higher level of protection against moisture contamination, than an unspecified coating may do, and advantage may be taken in the further reduction in separation distances. Additionally, both Type 1 and Type 2 coating are considered to provide full environmental protection against the effects of condensation, so would negate the requirement in Annex H, for pollution degree 2, or equivalent, for those parts of the circuit board covered with the Type 1 or Type 2 coating.

A solder mask not meeting the requirements of a Type 1 or Type 2 coating is not considered as a coating, but may be accepted as one of the two coats when an additional coat is applied, provided the solder mask is not damaged during soldering.

NOTE It is not the intent of 4.4 to increase the requirements for coatings beyond those of industrial equipment. Requirements for coatings can be found in IEC 60664-3 and UL 746E. Coatings in accordance with UL 746E are considered equivalent to Type 1 coatings. [the reference to UL 746E is included for alignment with the current draft text for IEC 60079-11, Ed 7 and may be revised to align with the final agreed text of IEC 60079-11]

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4.5 Solid electrical insulating materials

There are no specified distances through solid insulation, including encapsulation, in this standard, as the specified distances for industrial equipment, the requirements for the thermal stability of the insulating material, and dielectric tests are considered to provide the required level of safety for the applicable EPL.

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4.5.1 Specification

The specification for insulating material applies to materials supporting current-carrying parts in position or defining separation distances, but does not apply to interconnecting wiring or printed circuit board mounted components. The specification shall include the following:

- a) the name or registered trademark of the material manufacturer;
- b) the identification of the material;
- c) the possible surface treatments, such as varnishes, etc.;
- d) long-term thermal stability of the material (such as the TI per IEC 60216-1, RTI per ANSI/UL 746B, or other rating systems establishing long term continuous operating temperature, e.g. 20 000 hour, ratings of the material),
- e) when applicable, the comparative tracking index (CTI) determined in accordance with IEC 60112;
- f) when the insulating material is part of the external enclosure, the temperature index TI, corresponding to the 20 000 h point on the thermal endurance graph without loss of flexural strength exceeding 50 %, determined in accordance with IEC 60216-1 and IEC 60216-2 and based on the flexing property in accordance with ISO 178. If the material does not break in this test before exposure to the heat, the index shall be based on the tensile strength in accordance with ISO 527-2 with test bars of Type 1A or 1B. As an alternative to the TI, the relative thermal index (either RTI - mechanical strength or RTI - mechanical impact) may be determined in accordance with ANSI/UL 746B.

NOTE It is not a requirement of this standard that conformity to the manufacturer's specification of the insulating material needs to be verified.

4.5.2 Long-term thermal stability

The long-term thermal stability rating of materials supporting current-carrying parts in position or defining separation distances, other than interconnecting wiring and printed circuit board mounted components, shall be:

- a) for Level of Protection "eb", at least 20 K above the maximum service temperature, and at least 80 °C,
- b) for Level of Protection "ec", at least equal to the maximum service temperature, or for insulated windings, see 4.7.3 and Table 4.

Insulating parts made of plastics or laminates, where the original surface is removed during manufacture, shall be coated with an insulating varnish having at least the same grading according to

CTI as the original surface. This requirement does not apply to materials where these actions have not affected the grading according to CTI or where the specified creepage distance is provided by other parts not subjected to these actions.

4.6 Windings

4.6.1 General

The requirements of 4.6.2 to 4.6.5 apply to Level of Protection “eb” only, and not to Level of Protection “ec”.

4.6.2 Insulated conductors

Insulated conductors shall conform to either one of the following requirements:

- a) The conductors shall be covered with at least two layers of insulation, only one layer of which may be enamel; or
- b) Enamelled round winding wires shall be in accordance with either:
 - grade 1 of IEC 60317-3, IEC 60317-8, IEC 60317-13, or IEC 60317-46 provided that:
 - when tested in accordance with Clause 13 of IEC 60317-3, IEC 60317-8, IEC 60317-13, or IEC 60317-46 there shall be no failure with the minimum values of breakdown voltage listed for grade 2; and that
 - when tested in accordance with Clause 14 of IEC 60317-3, IEC 60317-8, IEC 60317-13, or IEC 60317-46 there shall be not more than six faults per 30 m of wire irrespective of diameter; or
 - grade 2 of IEC 60317-3, IEC 60317-8, IEC 60317-13, or IEC 60317-46; or
 - grade 3 of IEC 60317-8.

NOTE It is not a requirement of this standard that conformity to the specification of the enamel grade be verified.

4.6.3 Winding impregnation

Windings, after having been fastened or wrapped, shall be dried to remove moisture before impregnation with a suitable substance. Except as limited herein, dipping, trickling or vacuum pressure impregnation (VPI) is acceptable. Coating by painting or spraying is not recognized as impregnation.

NOTE The VPI process is considered to adequately remove moisture prior to impregnation.

The impregnation shall be carried out in accordance with the specific instructions of the manufacturer of the impregnating substance used and in such a way that the spaces between the conductors are filled as completely as possible and that good cohesion between the conductors is achieved.

This does not apply to fully insulated coils and conductors of windings if, prior to their fitting into the electrical equipment, the slot portions and end windings of these coils and conductors have been impregnated, provided with filling material, or otherwise insulated in an equivalent manner, and if, after assembly, they are no longer accessible for the stated insulating procedures.

If impregnating substances containing evaporating solvents are used for dipping or trickling, the dipping or trickling and drying processes shall be carried out at least twice.

4.6.4 Conductor dimensions

The minimum nominal conductor dimension of wires used for windings shall be 0,25 mm.

NOTE: The minimum dimension is the diameter of a round conductor or the smallest dimension of a rectangular conductor.

4.6.5 Sensing elements

Sensing elements of embedded temperature detectors (ETDs) are not considered to be windings, but when applied to the windings of electric machines, they shall be impregnated or sealed with the windings by the manufacturer.

When ETDs are applied in electric machines with a rated voltage exceeding 1 kV, the ETD and its connecting leads shall be located in or adjacent to an earthed area. A means of satisfying this requirement is to locate the ETD between two winding layers, each of which is bound by a conductive covering prior to insertion in the slots. The ETD connecting leads could be routed adjacent to the core end immediately upon leaving the slot and routed to the terminal box avoiding any winding connections.

Other sensing elements, including those that incorporate make/break constructions, shall employ a Type of Protection suitable for the application.

Note Motors of duty type S1, S2, S6, or S9 can be subjected to conditions during normal service that result in the activation of the protection circuit based on input from the sensing element.

4.7 Limiting temperature

4.7.1 General

4.7.1.1 Thermal stability of insulating materials

No solid electrical insulating material shall attain a temperature in excess of that defined by 4.5.2 when tested under rated conditions. Determination shall be in accordance with the procedure for the determination of service temperature in IEC 60079-0.

4.7.1.2 Maximum surface temperature

Furthermore, no surface of any part of electrical equipment, including the surface of internal parts to which the explosive gas atmosphere might have access, shall attain a temperature in excess of the maximum surface temperature prescribed in IEC 60079-0 except for lamps in luminaires for which the requirement is given in 5.3.7.2. The determination of the maximum surface temperature specified in IEC 60079-0 shall consider the additional overload or malfunction conditions defined in Table 3 of this standard and considering the test configuration described by the [relevant](#) industrial standard.

Deleted: applicable

Table 3 – Conditions for the determination of maximum surface temperature

Type of electrical equipment	Overload or malfunction conditions in addition to the conditions of IEC 60079-0	
	Level of Protection "eb"	Level of Protection "ec"
Luminaires	Per 5.3	Per 5.3
Electric machines	Per 5.2.8	None
Resistors	None	None
Terminals	None	None
Electromagnets	Worst-case air-gap	Worst-case air-gap
Other equipment	As specified by the relevant standard for industrial equipment	As specified by the relevant standard for industrial equipment as normal operating conditions

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Deleted: applicable

4.7.2 Conductors

In determining the temperature of the conductors, both the self-heating of the conductors and the effect of heating by neighbouring parts shall be taken into account.

1197 The permissible temperature of conductors and other metal parts is further limited by :

- 1198 a) reduction of mechanical strength;
 1199 b) unacceptable mechanical stress due to thermal expansion; and
 1200 c) damage to neighbouring electrical insulating parts.

1201 4.7.3 Insulated windings

1202 The maximum temperatures of insulated windings shall not exceed the values given in
 1203 Table 4 which take account of the thermal endurance of electrical insulating materials, provided that
 1204 the electrical equipment still complies with the requirements of 4.7.1.

1205 **Table 4 – Maximum permissible temperatures for insulated windings**

	Method of temperature measurement	Thermal class according to IEC 60085 (see b)									
		105 (A)		120 (E)		130 (B)		155 (F)		180 (H)	
		"eb"	"ec"	"eb"	"ec"	"eb"	"ec"	"eb"	"ec"	"eb"	"ec"
Maximum service temperature (°C) under normal operation: insulated single layer winding	Resistance or thermometer	95	105	110	120	120	130	130	150	155	175
Maximum service temperature (°C) under normal operation: other insulated windings	Resistance	90	100	105	115	110	120	130	145	155	165
	Thermometer (See a)	80	N/A	95	N/A	100	N/A	115	N/A	135	N/A
	Embedded sensor Output > 5 MW or 5 MVA	95	105	110	120	120	125	135	150	160	170
	Embedded sensor >200 kW or 200 kVA ≤ Output ≤ 5 MW or 5 MVA	95	105	110	120	120	130	135	155	160	175
Maximum motor winding temperature (°C) at end of time t_E or at time of switch off by embedded temperature sensor (see c)	Resistance	160	N/A	175	N/A	185	N/A	210	N/A	235	N/A
The sensor may be inside and/or outside the electrical equipment. Electrical faults in insulated windings are excluded. The requirements of 4.6 and 4.7 are intended to reduce the likelihood of such faults. a Measurement by thermometer is permissible only when measurement by change of resistance is not possible. In this context, 'thermometer' has the same meaning as in IEC 60034-1 (for example, a bulb thermometer, or a non-embedded thermocouple or resistance temperature detector (RTD) applied to the points accessible to the usual bulb thermometer). b As an interim measure until values have been prescribed, the higher thermal classes of insulating material denoted by figures in IEC 60085 are considered as subject to the limiting temperatures given for class 180 (H). c These values result from the summation of the effects of ambient temperature, the temperature rise of the winding in rated service and the further increase of temperature during time t_E. Where the motor winding is protected by embedded sensors, the temperature is determined at the time the motor is switched off after the locked rotor.											

1206 4.8 Wiring internal to equipment

1207 Wiring which might come into contact with a conductive part shall be mechanically protected, secured,
1208 or routed to minimize the likelihood of insulation damage.

1209 4.9 Degrees of protection provided by enclosures

1210 4.9.1 General

1211 The degrees of protection as defined in tests of enclosures of IEC 60079-0, as applicable, shall be as
1212 prescribed in a), b), or c) unless otherwise specified in 4.9.2, 4.9.3, or Clause 5.

1213 a) Enclosures containing bare conductive live parts shall provide at least the degree of protection
1214 IP54.

1215 b) Enclosures containing only insulated conductive live parts as in 4.5 shall provide at least the
1216 degree of protection IP44.

1217 c) Enclosures for electric machines containing only insulated conductive live parts as in 4.5, can
1218 provide a reduced degree of protection of IP23 for Group I, or IP20 for Group II, if solid foreign bodies
1219 are prevented from falling vertically through any openings into the enclosure. For this equipment, the
1220 certificate number shall include the "X" suffix in accordance with the marking requirements of
1221 IEC 60079-0 and the Specific Conditions of Use listed on the certificate shall include the following text,
1222 or equivalent.

1223 "The equipment shall be installed in a location where solid foreign bodies cannot fall vertically
1224 through any openings into the enclosure."

1225 An example of an application where this reduced degree of protection could be suitable is a clean
1226 environment.

1227 For Level of Protection "ec", opening of the enclosure for maintenance purposes, is not considered
1228 normal operation, and the opening times requirement of IEC 60079-0 does not apply.

1229 NOTE: The degree of protection requirements from relevant industrial standards are not applied directly for the evaluation of
1230 the explosion protection of Ex Equipment.

1231 The bars and rings of rotor cages are not considered to be bare live parts when determining the
1232 degree of protection.

1233 4.9.2 Drain holes or ventilation openings

1234 The enclosure of electrical equipment may be provided with drain holes or ventilation openings to
1235 prevent the accumulation of condensation. The requirements are dependent upon the equipment
1236 grouping as follows:

1237 a) Equipment Group I – compliance with 4.9.1 is required.

1238 b) Equipment Group II – the inclusion of the drain holes or ventilation openings may reduce the
1239 degree of protection provided by the enclosure according to 4.9.1, but shall not be below IP44 for
1240 item a) of 4.9.1 or IP24 for item b) of 4.9.1.

1241 When the presence of drain holes or ventilation openings reduces the degree of protection below the
1242 requirements of 4.9.1, the details of the drain holes or ventilation openings, including position and
1243 dimensions, shall be stated by the manufacturer and included in the descriptive documents in
1244 accordance with IEC 60079-0. For equipment with drain holes and ventilation openings that reduce the
1245 degree of protection, the certificate number shall include the "X" suffix in accordance with the marking
1246 requirements of IEC 60079-0 and the Specific Conditions of Use listed on the certificate shall detail
1247 the reduced degree(s) of protection provided by enclosure and note that environmental dust may enter
1248 the enclosure and compromise the electrical creepage and clearance.

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Deleted: and the entry of water do not compromise Type of Protection "e"...

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